



*Sridhar Seetharaman*

Carnegie Mellon University

Department of Materials Science and Engineering

Pittsburgh, PA 15213-3890

# **Development of a High Temperature Maximum Bubble Pressure Apparatus For Measuring Surface Tension of Molten Metals**

**DMR-0112792**



*Sridhar Seetharaman*

**Carnegie Mellon University**

**Department of Materials Science and Engineering**

**Pittsburgh, PA 15213-3890**

## **Objectives**

- The overall objective of this program is to develop an experimental methodology to measure surface tensions of liquid alloys under controlled oxygen contents in the gas.
- This will be used for characterizing surface tension of melts containing reactive elements such as Al, Cr and Ti. The effect of oxygen potential on the surface tension and surface phases will be elucidated and the results will be used to improve the understanding of surface physical chemistry of metallic melts and to address current industrial problems.



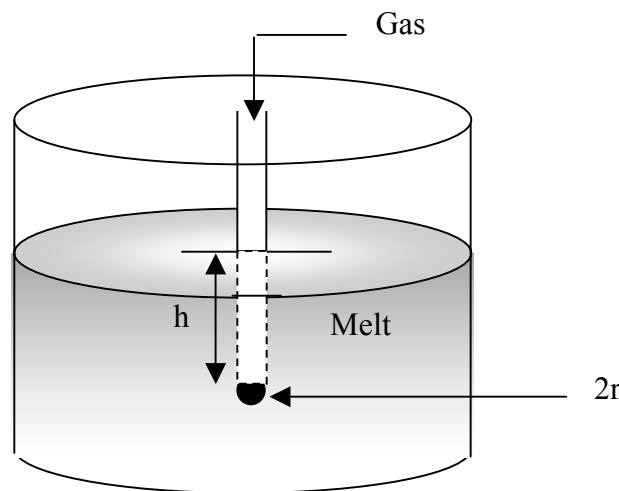
*Sridhar Seetharaman*

**Carnegie Mellon University**

**Department of Materials Science and Engineering**

**Pittsburgh, PA 15213-3890**

# Principle behind MBP



- The pressure needed to form a bubble at the tip of the tube is registered.
- The maximum bubble pressure ( $P$ ) to form a bubble is related to the surface tension and to the pressure necessary to create a new surface ( $P_\gamma$ ) through the equation:.

$$\gamma = \frac{P_\gamma r}{2} \left[ 1 - \frac{2}{3} \left[ \frac{r \rho g}{P_\gamma} \right] - \frac{1}{6} \left[ \frac{r \rho g}{P_\gamma} \right]^2 \right]$$



*Sridhar Seetharaman*

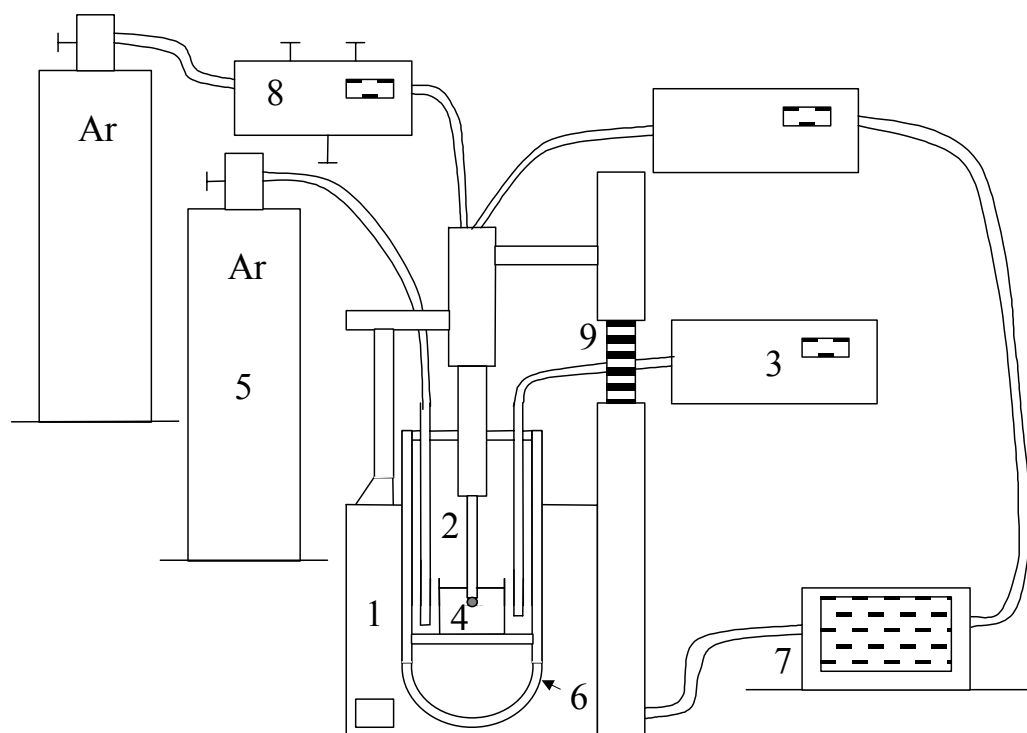
**Carnegie Mellon University**

**Department of Materials Science and Engineering**

**Pittsburgh, PA 15213-3890**

# MBP apparatus used for molten metals

- (1) Furnace
- (2) Zr-oxide capillaries for oxygen monitoring.
- (3) Pt/Pt-Rh thermocouple
- (4) Alumina crucible
- (5) Ambient oxygen-gettered gas
- (6) Protective alumina tube
- (7) Pressure transducer.
- (8) With the help of a gas flow controller
- (9) Capillary lifting device





*Sridhar Seetharaman*

**Carnegie Mellon University**

**Department of Materials Science and Engineering**

**Pittsburgh, PA 15213-3890**

## **Planned Industrial Collaboration**

- After completion of the instrument and calibration, projects will be initiated to study surface tensions of molten reactive alloys such as stainless steels and other high alloy steels together with industrial collaborators at the Center for Iron and Steelmaking (an NSF initiated center which is now industrially funded).

## **Planned Educational Aspects**

- The instrumentation will be incorporated in laboratory classes to study properties of molten metals.